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Large Hadron Collider
Magnet Division Procedure

Proc. No.: LHC-MAG-R-1005

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Class: Dipole
Title: 2.95 m Dipole Shell Welding Assembly

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REVISION RECORD

Rev. No.	Date	Page	Subject	Approval
A	8/24/99		Initial Release.	

1. Scope:

This specification describes the procedure for longitudinal seam welding of the 2.95 m LHC Prototype Dipole Cold Mass Assembly.

2. Applicable Documents:

The following documents, of the issue in effect at the time of release for manufacture, form a part of this procedure to the extent specified herein:

RHIC-MAG-Q-1004	Discrepancy Reporting Procedure
RHIC-MAG-Q-1000	Procedure For Control of Measurement Test Equipment

BNL Drawings:

14010058	Assembly, LHC Prototype Dipole, Shell Welding

3. Requirements:

The Dipole Cold Mass Assembly shall be welded in accordance with this specification and associated drawings.

All welding must be performed by welders qualified in accordance with ASME Section IX.

3.1 Material/Equipment

25-1448.06-4 Invar Rod and Micrometer Assembly
25-1717.04-5 Shell Weld Fixture Stand Assembly
25-1717.05-5 Shell Weld Fixture Air Cylinder Support Assembly
25-1717.47-5 Lifting Beam Assembly
25-1784.02-5 Roller Support
25-1784.03-5 Roller Support

3.2 Safety Precautions

3.2.1 Operators shall be trained by their cognizant technical supervisor and qualified in the operation of the required welding equipment.

3.2.2 No welding shall take place unless all welding screens are in place around the welding station, and all personnel not directly involved with the welding process are outside the screens. Any personnel inside the screens shall wear protective gear to prevent eye injury, and shall be clothed to prevent burns caused by intense ultra-violet light.

3.2.3 All lifting and handling operations requiring overhead crane operations shall be performed by holders of valid Safety Awareness Certificates and trained in the use of the lifting device by the Cognizant Engineer or Technical Supervisor.

3.2.4 Some of the electrical test procedures have specific safety requirements. The technicians performing these specific tests shall rigorously follow all the safety requirements listed as well as those prescribed by the BNL ES&H Standard.

3.2.5 Hypot and impulse testing pose a Class "C" electrocution hazard. At least two properly trained technicians must be present to perform this testing. When testing, a trained technician shall be stationed at any point where the item under test is accessible to unauthorized people, and barriers shall be set up. Signs shall be posted reading "DANGER HIGH VOLTAGE" and warning lights shall be turned on.

3.3 Procedure

3.3.1 Weigh and Stack Lower Yoke

3.3.1.1 On the weight scale, stack end laminations for the LE until the weight equals 491.7 ± 1.4 lbs. Alternate between laminations with one notch and laminations with two notches.

3.3.1.2 Record the weight in the traveler and transfer the laminations to the rails on the shell welding fixture.

NOTE: When stacking laminations be sure all the notches are on the same side.

3.3.1.3 On the weight scale, stack center laminations until the weight equals approximately 1200 lbs.

3.3.1.4 Record the weight on the traveler and transfer the laminations to the rails on the shell welding fixture.

3.3.1.5 Repeat steps 3.3.1.3 - 3.3.1.4 four times until the total steel weight equals 4771.3 ± 1.4 lbs.

3.3.1.6 On the weight scale, stack end laminations for the NL until the weight equals 331.4 ± 1.4 lbs.

3.3.1.7 Record the weight in the traveler and transfer the laminations to the rails on the shell weld fixture.

3.3.1.8 Install the fixture stops and tie rods. Tighten to achieve the yoke lengths per the shell welding assembly drawing.

3.3.2 Collared Coil Installation.

3.3.2.1 Install two NL filler lamination packs in the lower yoke.

3.3.2.2 Lower the 2 collared coil assemblies into the lower yoke half. Center the collars in the yoke.

3.3.2.3 Measure and record, axial the lengths of the 4 coil halves using in Inver rod and micrometer assembly.

3.3.2.4 Install the yoke keys per the shell welding assembly drawing.

3.3.2.5 Install two NL filler lamination packs on the NL end collar packs.

3.3.3 Weigh and stack upper yoke.

3.3.3.1 Place the spacer bars on the lower yoke.

3.3.3.2 Repeat steps 3.3.1.1 - 3.3.1.8 stacking the laminations on the spacers above the lower yoke stacking fixture. Position upper yoke so that the notches in the upper yoke laminations are on the same side as the notches in the lower yoke laminations.

3.3.3.3 Lift the upper yoke, remove the spacer bars and lower the upper yoke into position on the lower yoke.

3.3.4 Shell Welding

3.3.4.1 Measure and record the shell lengths.

3.3.4.2 Place the upper half-shell over the yoke. Center it uniformly about the longest coil. Center it circumferentially relative to the yoke by measuring the height from the weld fixture base plate to the shell edges.

3.3.4.3 Install the backing strips. Center uniformly about the longest coil and secure with a few small tack welds.

3.3.4.4 Clamp the half-shell to the yoke by applying 60 psi to the air cylinders. Again check the edge position relative to the platten surface, verifying that the half-shell is still circumferentially centered after it is fully clamped. Verify with .002 feeler gauges that no gap exists between yoke survey notches and the rails over the entire length.

3.3.4.5 Use c-clamps, located between the cylinders, to draw in the edges of the shell.

3.3.4.6 Make a continuous fillet weld of the backing strip to the lower yoke using 12010441-03. Use two certified welders, remaining in-step along the length.

3.3.4.7 Fillet weld the upper half shell to the backing strip using 12010441-03. Welds shall be 2" long every 6" minimum. Use two certified welders, remaining in-step along the length. Start at the lead end and progress to the non-lead end. Leave the last three inches at each end unwelded in order to slide in the end plate later.

3.3.4.8 Unclamp the yoke assembly and remove the air cylinder support assembly. Lift the yoke and place it on the rotating supports with the lower half shell. Rotate 180^0 (the welded half-shell is now down).

3.3.4.9 Place the yoke assembly on support feet. At the shell hole locations, the tooling will fit through holes in the shell, directly engaging the yoke lamination survey flats.

3.3.4.10 Center the lower half-shell longitudinally with respect to the upper half-shell. Center it circumferentially relative to the upper half-shell so that a uniform gap exists between the two half-shell edges.

3.3.4.11 Clamp the assembly by applying 60 psi to the air cylinders. Again check the gap between the half-shells and their longitudinally alignment. The clamping must not make the half-shell gap uneven.

3.3.4.12 Check the yoke assembly with .002 feeler stock for full contact with the fixture in all support locations.

3.3.4.13 Use the c-clamps, located between the cylinders to draw in the edges of the shell.

3.3.4.14 Tack weld the shell halves together using filler wire (P/N 12010441-03). Tacks shall be in the same location as the bottom shell tacks. Use two certified welders, remaining in-step along the length. Start at the lead end and progress to the non-lead end. Leave the last three inches at each end unwelded in order to slide-in the end plate later.

3.3.4.15 Make TIG root passes on each longitudinal seam using filler wire (P/N 12010441-03). Use two certified welders, remaining in-step along the length. Leave the last three inches at each end unwelded in order to slide-in the end plate later.

3.3.4.16 Make a cover pass on each longitudinal seam by manually TIG welding using filler wire (P/N 12010441-03) or by MIG welding using hand held MIG guns and filler wire (P/N 12010441-02). Use two certified welders, remaining in-step along the length. Leave the last three inches at each end unwelded in order to slide-in the end plate later.

3.3.4.17 Unclamp the assembly and remove the air cylinder support assembly.

3.3.4.18 Measure and record the lengths of the 4 coil halves using the Invar rod and micrometer assembly.

3.3.4.19 After shell weld has cooled measure and record the shell lengths.

3.3.5 Quench heater termination

3.3.5.1 Install the quench heater mounting boards as shown on the assembly drawing.

3.3.5.2 Fold each heater over 14 gauge wire and solder as shown on the assembly drawing.

3.3.5.3 Install quench heater clamps as shown on the assembly drawing.

3.3.6 Electrical Testing

DANGER: Be sure the "Hypot", yoke, and beam tube is grounded at all times. Failure to observe this caution may result in electrocution.

3.3.6.1 Perform a coil-to-coil hypot check at 3 kV, following RHIC-MAG-R-7242.

NOTE: The leakage current must be less than 50 μa.

3.3.6.2 Electrically connect the main coil leads together.

3.3.6.3 Perform a hypot check between the main coils and the yoke at 5 kV, attaching the grounded lead of the hypot tester to the yoke/shell following RHIC-MAG-R-7242.

NOTE: The leakage current must be less than 50 μa.

3.3.6.4 Measure coil temperature. Measure voltage drops across coil at 1 amp DC, following RHIC-MAG-R-7320. Complete the measurements of inductance and quality factor (Q) following RHIC-MAG-R-7228.

3.3.6.5 Perform a hypot check between the collars and each of the quench protection resistors at 2.5kV attaching the grounded lead of the hypot tester to the yoke/shell following RHIC-MAG-R-7242.

4. Quality Assurance Provisions:

4.1 The Quality Assurance provisions of this procedure require that all assembly and test operations be performed in accordance with the procedural instructions contained herein.

4.2 Measuring and test equipment used for this procedure shall contain a valid calibration label in accordance with RHIC-MAG-Q-1000.

4.3 All discrepancies shall be identified and reported in accordance with RHIC-MAG-Q-1004.

5. Preparation for Delivery:

N/A

Yoke Weight

	Lower	Upper
LE		
Center # 1		
Center # 2		
Center # 3		
Center # 4		
NL		
Total/Half		
Total		

Coil Length

	Left Lower	Left Upper	RT Lower	RT Upper
Before Welding				
After Welding				

Shell Length

	Lower	Upper
Before Welding		
After Welding		

Appendix A

LHC 2.95 m Prototype
Yoke Weight Calculation

Total Yoke Length = 123.659 in.

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- End lamination length LE = 11.571 in
- Center lamination length = 104.286 in.
- End lamination length NL = 7.799 in.

The surface area of a center yoke lamination = 163.300 in^2
The surface area of an end yoke lamination = 151.675 in^2

Center Laminations:

Packing factor = 99.0%
Weight = 2x (104.286 in. x 163.300 in^2 x .283 lb/in^3 x .99)
= 9542.5 lbs. ± 2.8 lbs.

End Laminations:

Packing factor = 99.0%
LE weight = 2x (11.571 in. x 151.675 in^2 x .283 lb/in^3 x .99)
= 983.4 lbs. ± 2.8 lbs.
NL weight = 2x (7.799 in. x 151.675 in^2 x . 283 lb/in^3 x .99)
= 662.8 lbs. ± 2.8 lbs.

The ± 2.8 lb. tolerance is based on the weight of a single lamination.